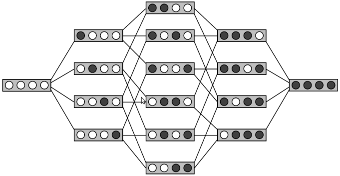
Wrappers



Learning goals

- Add Learning goals

WRAPPERS

- Wrapper methods emerged from the idea that different sets of features can be optimal for different classification learners.
- Given a set of features, we can use the classifier itself to assess their quality.
- We could just evaluate on the test set or use resampling techniques to achieve this.
- A wrapper is nothing else than a discrete search strategy for S, where the cross-validated test error of a learner as a function of S is now the objective criterion.

WRAPPERS

There are a lot of varieties of wrappers. To begin with we have to determine the following components:

- A set of starting values
- Operators to create new points out of the given ones
- A termination criterion

WRAPPERS

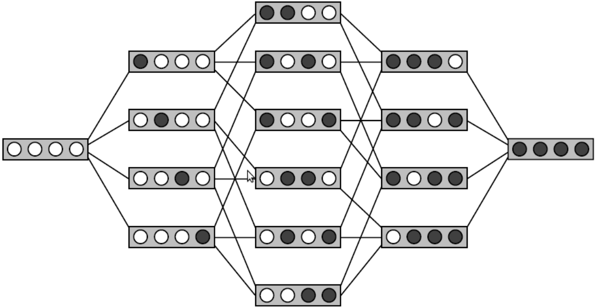


Figure: Space of all feature sets for 4 features. The indicated relationships between the sets insinuate a greedy search strategy which either adds or removes a feature.

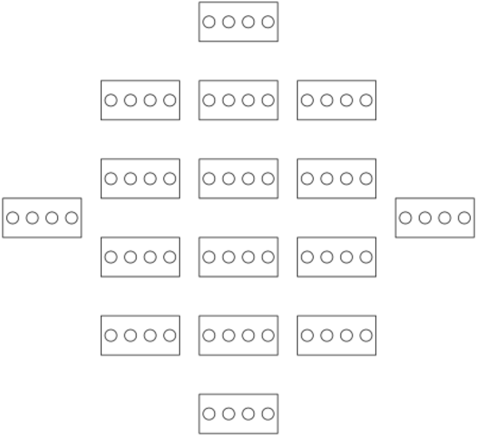
WRAPPERS

Greedy forward search:

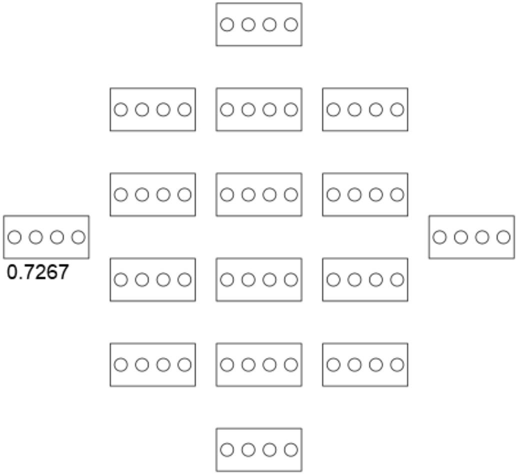
- Let $S \subset \{1, \ldots, p\}$, where $\{1, \ldots p\}$ is an index set of all features.
- Start with the empty feature set $S = \emptyset$.
- For a given set S, generate all $S_j = S \cup \{j\}$ with $j \notin S$.
- Evaluate the classifier on all S_j and use the best S_j.
- Iterate over this procedure.
- Terminate if:
    - the performance measure no longer shows relevant improvement,
    - a maximum number of features is used, or
    - a given performance value is reached.

WRAPPERS

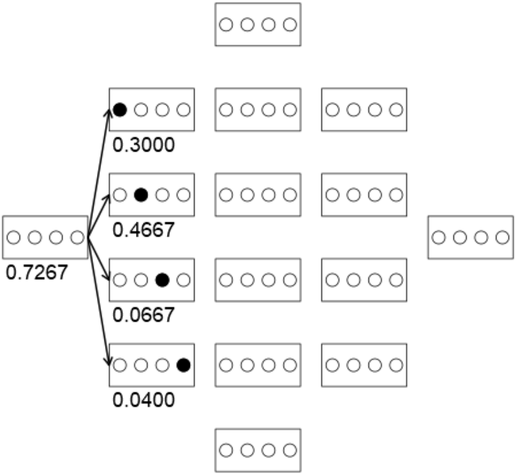
Example for greedy forward search on iris data:



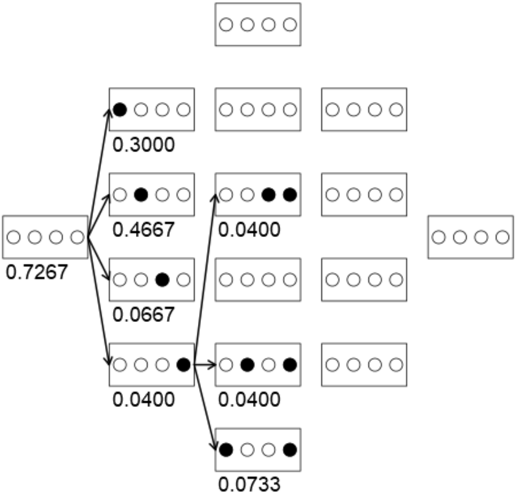
WRAPPERS



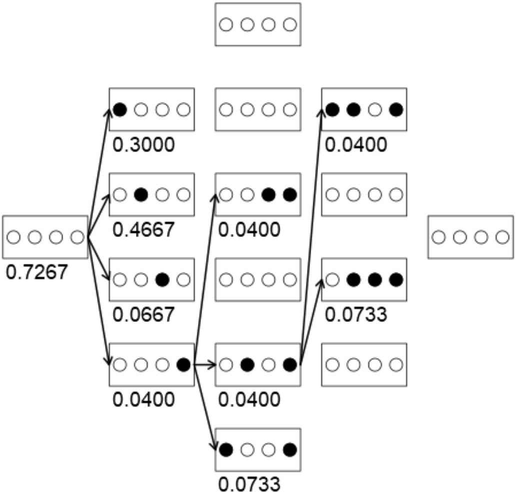
WRAPPERS



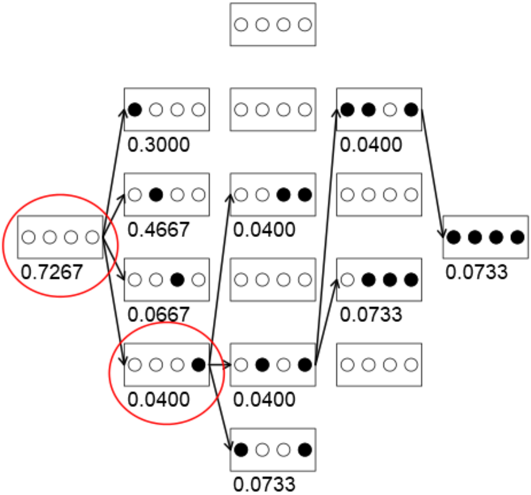
WRAPPERS



WRAPPERS


0.3000
0.0400
0.4667
0.0400
0.7267
0.0667
0.0733
0.0400
0.0400
0.0733

WRAPPERS


0.3000
0.4667
0.7267
0.0667
0.0400
0.0400
0.0400
0.0733
0.0400
0.0733
0.0733

WRAPPERS

Greedy backward search:

- Start with the full index set of features $S = \{1, \dots, p\}$.
- For a given set S generate all
  $S_j = S \setminus \{j\}$ with $j \in S$.
- Evaluate the classifier on all S_j and use the best S_j.
- Iterate over this procedure.
- Terminate if:
    - the performance drops drastically, or
    - a given performance value is undershot.

WRAPPERS

Extensions:

- Eliminate or add several features at once to increase speed.
- Allow alternating forward and backward search.
- Randomly create candidate feature sets in each iteration.
- Continue search based on the set of features where an improvement is present.
- Use improvements of earlier iterations.

WRAPPERS

Algorithm A simple 1+1 genetic algorithm

Start with a random set of features S (bit vector b).
repeat
    Flip a couple of bits in b with probability p.
    Generate set S' and bit vector b'.
    Measure the classifier's performance on S'.
    If S' performs better than S, update $S \leftarrow S'$, otherwise $S \leftarrow S$.
until One of the following conditions is met:

- A given performance value is reached.
- Budget is exhausted.

WRAPPERS

Advantages:

- Can be combined with every learner.
- Can be combined with every performance measure.
- Optimizes the desired criterion directly.

Disadvantages:

- Evaluating the target function is expensive.
- Does not scale well if number of features becomes large.
- Does not use much structure or available information from our model.